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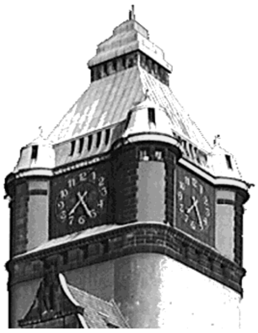

Transparency in the Banking Sector

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Abstract:

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1 Introduction

The extensive literature on optimal choice under risk has shown that, in general, the impact of uncertainty on the behavior of risk-averse decision makers is ambiguous. In particular, risk aversion alone is insufficient to assess the marginal impact of uncertainty on saving, investment, and production (Leland, 1968; Sandmo, 1971). This ambiguity also applies to the behavior of banks acting as intermediaries between savers and investors.[1] The issue is further complicated by the fact that the precise meaning of uncertainty, and the right way to model it, is not beyond dispute in the literature. With regard to the banking sector, it appears that uncertainty cannot appropriately be captured by standard dispersion concepts such as variances or mean preserving spreads. Our paper therefore proposes an information-based concept of uncertainty and, in this setting, revisits the link between uncertainty and bank behavior.

[1] See, for example, Boyd and De Nicolò, 2005; Keeley, 1990; Matutes and Vives, 1996; Eichner and Wagener, 2004; to name just a few.

In standard models of the banking firm's behavior, the bank acts in an *exogenously* given uncertain environment.[2] Yet, viewed from a broader perspective, the uncertainty under which deposit/loan-portfolios are chosen by banks is endogenous and depends on the available (public) information in the economy. In our paper we take this important feature into account: we endogenize the uncertainty in the banking sector through an information system that conveys signals about the return distribution of bank loans extended to private investors. If the information system is more precise, the random return on a loan can be assessed more accurately thereby reducing the uncertainty faced by the bank.[3]

Assuming that risk sharing arrangements exist where banks can hedge (partially or fully) the return risks of their loan portfolios, an exogenous reduction of uncertainty is not the same as a decline of uncertainty due to a more precise information system. In fact, the greater reliability of the information signals may change the terms of trade on the risk sharing markets and thus affect the bank's portfolio decision. Due to this interaction, standard models of banking do not properly capture the mechanisms through which endogenous, i.e., information-induced, changes of uncertainty affect optimal bank behavior.

We consider the banking sector to be more transparent if it is endowed with a more reliable information system about the distribution of risky loan returns. As argued above, in general higher transparency is not equivalent to an exogenous reduction of the return uncertainty. Instead, our transparency concept is linked to the reliability of a publicly observable signal that is correlated with the random return on loans. By conveying some noisy information about the unknown loan return, the signal allows the bank to update its beliefs in a Bayesian manner. The banking sector is said to be more transparent if the signal is 'less noisy', i.e., if it conveys more reliable information.

Within this setting our analysis focuses on the activity of a bank in performing

[2]See, for example, Wong, 1997, 2011; Flood and Marion, 2004; Freixas and Rochet, 2008; Bannier, 2010; Buckley, 2011.

[3]In this paper we use the notions 'risk' and 'uncertainty' interchangeably. Yet, we distinguish between *ex ante* uncertainty which refers to the prior distribution of loan returns, and *ex interim* uncertainty which refers to the distribution of loan returns conditional on a signal observation.

a special type of financial intermediation. The bank extends risky loans to investors and sells deposits to savers at fixed rates. These rates are determined competitively and are not explained by our model. To incorporate risk sharing, we assume that the bank has access to a futures market where it can hedge the return risk of its loan portfolio conditional on the realization of the public signal. We find that higher transparency in the banking sector always raises expected bank profits, but may lead to a higher or lower expected loan volume. Which case occurs depends on the curvature of marginal loan management costs: if the marginal cost function is concave, then more transparency raises the expected volume of bank loans; and if the marginal cost function is convex, then more transparency leads to a lower expected loan volume. Moreover, unless risk aversion is very low, economic welfare is not necessarily positively related to the degree of transparency in the banking sector. In fact, if the bank is strongly risk-averse, more transparency may well lead to lower economic welfare.

Before turning to the analysis, let us place our contribution in the broader context of the literature on banking and investment financing decisions under uncertainty. By the choice of the transparency criterion, our study is conceptually related to the literature on the modeling and analysis of information structures that emerged from Blackwell (1953). According to Blackwell's approach, an information structure generates random observable signals which are correlated to the unknown future state of the world. The precision of these signals affects the uncertainty under which the agents make their choices. This strand of literature has analyzed the link between the precision of information structures, optimal individual behavior, and economic welfare both in partial equilibrium settings (Sulganik and Zilcha, 1997; Wakker, 1988) and in full equilibrium (Hirshleifer, 1971, 1975; Green, 1981; Citanna and Villanacci, 2000; Eckwert and Zilcha, 2003).

Our paper is also related to the literature on optimal choice under uncertainty with incomplete risk sharing arrangements. This literature has investigated in various market settings the role of specific risk factors on the behavior of risk-averse economic agents (Leland, 1968; Sandmo, 1970, 1971; Gollier, 1995). By focusing on the intertemporal nature of investment decisions, more recent studies have pointed out that traditional investment rules can be misleading if they fail to properly take into account the opportunity cost of investing (Caballero, 1991; Thijssen, Huisman and Kort, 2006; Wong, 2007). Our paper also builds, of course, on the literature on the modeling of a banking firm. This literature describes how a banking firm acts as an intermediary between savers and investors (Klein, 1971; Freixas and Rochet, 2008). In the simplest setting, the banking firm sells risk-free deposits to savers and extends risky loans to private investors. Typically, the bank is modelled as a risk-averse agent who tries to diversify the loan risk and charges a risk premium on those risks that cannot be diversified.

In light of the extant literature, the contribution of the current paper is to analyze a banking firm's behavior when uncertainty and terms of risk sharing vary endogenously with the precision of an information system.

2 The Model

We develop a simple model of an investment banking firm with a two period time horizon. The dates are indexed $t = 0$ and $t = 1$. At time $t = 0$, the bank is endowed with fixed equity capital, K, and issues deposits, D. The gross rate of return on deposits at $t = 1$ is $1+r_D$. The equity capital and the deposits are used to extend loans, L, for the funding of private investment projects. As these investment projects are risky, the loans (including interest) will not always be paid back in full. We do not model the loan repayment mechanism explicitly here. Instead we capture the implied risk for the bank by a random gross return on loans, $\tilde{r}$, with support $\Omega = [\underline{r}, \bar{r}]$, $0 < \underline{r} < \bar{r} < \infty$, and with (prior) probability density function, $f(r)$.[4]

The bank chooses its portfolio of deposits and loans (D, L) after it has learned the realization of a publicly observable random information signal, $\tilde{y}$, about the state of the economy. The signal $\tilde{y}$ takes values in $Y \subset \mathbb{R}$. This signal, which may be released by the central bank, the government, or some economic forecasting agency, is correlated with the random return on loans and thus contains information about $\tilde{r}$. From the perspective of the bank which has observed the signal realization y, the return rate on each individual loan is random with distribution (density) $\nu(r|y)$.

[4]Throughout the paper, random variables have a tilde while their realizations do not.

Yet, we assume that there is no aggregate uncertainty in the economy, i.e., given the signal y, the *ex post* return distribution of all extended loans is exactly $\nu(r|y)$.[5]

The absence of aggregate uncertainty after realization of the signal implies, of course, that the return risk of loans is diversifiable, i.e., insurable with a risk premium equal to zero. To capture this aspect, in our model the bank has access to a futures market for hedging purposes. The futures market opens at $t = 0$ after the public signal has been revealed. Let r_F be the futures rate that is determined at $t = 0$. The bank sells (purchases if negative) H units of the futures at $t = 0$, which are settled at $t = 1$ at the then prevailing spot rate, $\tilde{r}$. Due to the diversifiability of the loan return risk, the futures market is unbiased, i.e.,

$$r_F(y) = E(\tilde{r}|y) = \int_\Omega r\nu(r|y)\,\mathrm{d}r, \tag{1}$$

for all $y \in Y$.

To ensure positive loan volumes, we assume that the futures rate is uniformly larger than the deposit rate, i.e., $r_F(y) > r_D$ for all y. According to (1), the futures rate depends on the signal only via the posterior probabilities $\nu(r|y)$. Moreover, the futures rate is linear in the posterior probabilities. We shall make use of this linear structure when we analyze the role of the signal's informativeness for the optimal bank portfolio.

The banking firm's random end-of-period profit, $\tilde{\Pi}$, is given by

$$\tilde{\Pi} = \tilde{r}L - r_D D - C(L) + (r_F(y) - \tilde{r})H, \tag{2}$$

where $C : \mathbb{R}_+ \to \mathbb{R}_+$ is a strictly increasing and convex function. This function satisfies $C(0) = C'(0) = 0$ and represents the cost of loan management. The bank's portfolio (D, L) needs to satisfy the balance sheet constraint

$$L = K + D. \tag{3}$$

The preferences of the bank are described by a von Neumann-Morgenstern utility function, $U(\Pi)$, defined over its operating profit at $t = 1$. The utility function is

[5]Feldman and Gilles, 1985, have shown that a probabilistic setting exists, where this version of a law of large numbers for large economies holds. In this setting, though, the individual conditional project return risks are not independent.

strictly increasing and concave, indicating risk aversion. At $t = 0$, the bank chooses a deposit/loan portfolio which satisfies (3), and a futures market position, H, so as to maximize the expected utility of its random profit at $t = 1$:

$$\max_{L,H} E[U(\tilde{\Pi})|y] = \int_{\Omega} U[rL - r_D(L-K) - C(L) + (r_F(y) - r)H]\nu(r|y)\,\mathrm{d}r, \quad (4)$$

where $\tilde{\Pi}$ is defined in Eq. (2). The first-order conditions for program (4) are given by

$$\begin{aligned} E\{U'(\tilde{\Pi}^*)[\tilde{r} - r_D - C'(L^*)]|y\} &= 0, & (5)\\ E[U'(\tilde{\Pi}^*)(r_F(y) - \tilde{r})|y] &= 0, & (6)\end{aligned}$$

where an asterisk (*) signifies an optimal level. The solution to Eqs. (5)-(6) is characterized by the following system of equations:

$$\begin{aligned} r_F(y) - r_D &= C'(L^*), & (7)\\ H^* &= L^*. & (8)\end{aligned}$$

In fact, Eqs. (8), (2), and (3) imply that

$$\Pi^* = r_F(y)L^* - r_D D^* - C(L^*), \quad (9)$$

is non-stochastic. Eq. (6) therefore follows from Eq. (1); and Eq. (5) follows from Eqs. (6) and (7).

Eq. (7) implies that the bank's optimal loan volume, L^*, is uniquely determined by equating the earnings from the margin, or spread, $r_F(y) - r_D$, to the marginal cost of managing the loans, $C'(L^*)$. Eqs. (7)-(8) establish for our model the validity of the separation and full-hedging hypotheses. These hypotheses claim that, in the presence of a futures market, entrepreneurial decisions are independent of attitudes towards risk and, moreover, that all risks will be fully hedged if the futures market is unbiased.[6] (7) yields the closed-form solution for the optimal loan volume which is given by $L^* = C'^{-1}(r_F(y) - r_D)$.

[6]See, for example, Kawai and Zilcha, 1986.

Notice that H^*, L^* and Π^* all depend on the publicly observable signal y through the forward rate $r_F(y)$. Before we analyze the resulting economic consequences of a more informative signal in Section 4, we first need to present our notion of transparency which is based on the signal's informativeness.

3 Transparency in the Market for Bank Loans

We identify the transparency of the loan market with the informativeness of the signal $y \in Y \subset \mathbb{R}$. The informativeness of the signal, in turn, depends on the information system within which signals can be interpreted (Blackwell, 1953). An information system, denoted by g, specifies for each state of nature, r, a conditional probability density function over the set of signals: $g(y|r)$. The positive real number $g(y|r)$ defines the conditional probability density that the signal y will be observed if the true gross return is r. The function $g(y|r)$ is common knowledge. Using Bayes's rule, the banking firm revises its expectations and maximizes expected utility on the basis of the updated beliefs.

Let $\pi : \Omega \to \mathbb{R}_+$ be the probability density function of the prior distribution over Ω. The probability density of the prior distribution over signals in Y is then given by

$$\nu(y) = \int_{\Omega} g(y|r) f(r)\, \mathrm{d}r \qquad \text{for all } y.$$

Using Bayes's rule, the density function for the updated posterior distribution over Ω is

$$\nu(r|y) = g(y|r) f(r)/\nu(y).$$

The concept of informativeness that we use in this paper is based on the Blackwell [1953] sufficiency criterion. Suppose $g^1(y|r)$ and $g^2(y|r)$ are two information systems with associated density functions $\nu^1(r|y)$ and $\nu^2(r|y)$, $(y, r) \in Y \times \Omega$. The following criterion induces an ordering on the set of information systems.

Definition *Let g^1 and g^2 be two information systems. Information system g^1 is said to be more informative than information system g^2 (expressed by $g^1 \succ_{\inf} g^2$), if there exists an integrable function $\lambda : Y^2 \to \mathbb{R}_+$ such that*

$$\int_Y \lambda(y', y)\, dy' = 1,$$

for all $y \in Y$, and

$$g^2(y'|r) = \int_Y g^1(y|r)\lambda(y', y)\, dy$$

for all $r \in \Omega$.

According to this criterion, $g^1 \succ_{\text{inf}} g^2$ holds if g^2 can be obtained from g^1 through a process of randomization. The probability density $\lambda(y', y)$ randomly transforms a signal y into a new signal y'. If the y' values are generated in this way, the information system g^2 can be interpreted as being obtained from the information system g^1 by adding random noise. Note that $\lambda(\cdot, \cdot)$ is independent of r. Therefore, the signals under information system g^2 convey no information about the realization of $\tilde{r}$ that is not also conveyed by the signals under information system g^1.

Our notion of the loan market's transparency is based on the informational content of the signal. The loan market is said to be more transparent, if it operates under a more informative system and, in this sense, the signal is less noisy. Thus, $g^1 \succ_{\text{inf}} g^2$ implies that the loan market is more transparent under g^1 than under g^2.

The following Lemma contains a property of information systems which can be used in our analysis.

Lemma 1 *Let g^1 and g^2 be two information systems. The loan market is more transparent under g^1 than under g^2, if and only if*

$$\int_Y G\big(\nu^1(\cdot|y)\big)\nu^1(y)\, \mathrm{d}y \overset{(\leq)}{\geq} \int_Y G\big(\nu^2(\cdot|y)\big)\nu^2(y)\, \mathrm{d}y$$

holds for every convex (concave) function $G(\cdot)$ on the set of density functions over Ω.

Note $\nu^1(\cdot|y)$ and $\nu^2(\cdot|y)$ are the posterior beliefs under the two information systems g^1 and g^2. Lemma 1 therefore implies that higher transparency (weakly) raises the expectation of any convex function of posterior beliefs. A proof of Lemma 1 is developed in Kihlstrom, 1984. Lemma 1 will be used in providing some of the main results in this paper.

4 Implications of Higher Transparency

In this section we analyze how transparency in the loan market is related to the bank's optimal loan portfolio, ex ante expected profits, and ex ante expected utility.

4.1 Loan Portfolio and Expected Profits

The key variable of interest for our comparative static exercise is r_F since the behavior of the bank depends on the information signal only via the futures rate. Differentiating Eq. (7) with respect to r_F yields

$$L^{*\prime}(r_F) = \frac{1}{C''(L^*(r_F))} > 0. \tag{10}$$

A higher futures rate raises the spread in the loan market which makes lending more profitable for the bank. Accordingly, the bank responds by expanding its loan portfolio.

Proposition 1 *Let $\bar{L}^*$ be the expected volume of bank loans before the signal, y, can be observed:*

$$\bar{L}^* = \int_Y L^*\big(r_F(y)\big)n(y)\,\mathrm{d}y. \tag{11}$$

More transparency in the loan market leads to a higher (lower) expected volume of bank loans, $\bar{L}^*$, if the marginal cost function, $C'(L)$, is concave (convex).

Proof By Eq. (1), r_F is linear in the posterior belief, $\nu(\cdot|y)$. It then follows from Eq. (11) and Lemma 1 that $\bar{L}^*$ increases (decreases) with more transparency if $L^*(r_F)$ is convex (concave) in r_F. Differentiating Eq. (10) with respect to r_F yields

$$L^{*\prime\prime}(r_F) = -\frac{C'''(L^*\big(r_F)\big)}{C''\big(L^*(r_F)\big)^2}. \tag{12}$$

The claim then follow from Eq. (12).

The intuition for the result in Proposition 1 is as follows. Observe from Eq. (9) that the bank's profit is higher for y' than for y, if and only if $r_F(y') > r_F(y)$. Let us therefore say that signal y' is 'better' than signal y, if it corresponds with a higher futures rate. We have seen above (cf. Eq. (10)) that the bank expands its loan portfolio if the futures rate increases. Hence, the loan volume is larger for good signals than for bad signals. With more transparency, a good signal becomes even better because now it is more reliable. As a consequence, the loan volume increases. For the same reason, a bad signal becomes even worse in a more transparent loan market and, consequently, the loan volume declines. If the marginal cost of managing the loans is increasing at a decreasing (an increasing) rate, the transparency-induced expansion of the bank's loan portfolio for good signals is larger (smaller) than the transparency-induced contraction of the loan portfolio for bad signals. As such, the ex ante expected loans volume goes up (down) if the marginal cost function is concave (convex).

If, e.g., the loan management costs are quadratic, the marginal cost function is linear. In that case, more transparency in the loan market has no effect on the ex ante expected size of the bank's loan portfolio. Alternatively, suppose that $C(L) = L^b$, where $b > 0$ is the constant elasticity of management costs. For $b \in (1, 2)$ the marginal cost function is concave such that more transparency in the loan market increases the ex ante expected loan volume; and for $b > 2$ the marginal cost function is convex, hence the loan volume shrinks with more transparency.

Our next proposition claims that ex ante expected bank profits are higher when the loan market is more transparent.

Proposition 2 *Let $\bar{\Pi}^*$ be the bank's expected profit before the signal, y, has been observed,*

$$\bar{\Pi}^* = \int_Y \Pi^*\big(r_F(y)\big)n(y)\,\mathrm{d}y. \tag{13}$$

More transparency in the loan market leads to a higher expected bank profit $\bar{\Pi}^*$.

Proof By Eq. (1), $r_F(y)$ is linear in the posterior belief, $\nu(\cdot|y)$. It then follows from Eq. (13) and Lemma 1 that $\bar{\Pi}^*$ increases with more transparency if $\Pi^*(r_F)$ is convex in r_F. Differentiating Eq. (9) with respect to r_F and using the envelope theorem yields

$$\Pi^{*\prime\prime}(r_F) = L^{*\prime}(r_F). \tag{14}$$

The convexity of $\Pi^*(r_F)$ then follows from Eq. (10).

To see the intuition for the mechanism in Proposition 2, note that

$$\Pi^{*\prime}(r_F) = L^*(r_F). \tag{15}$$

An increase in r_F has a first-order effect on the bank's maximum profit through the asset return. Since the bank extends more loans when r_F increases, this first-order effect on $\Pi^*(r_F)$ becomes stronger with larger r_F. As a result, the bank's profit function is convex in the futures rate and, hence, the bank benefits in terms of ex ante expected profits from more loan market transparency.

4.2 Welfare Effects of Market Transparency

Since the transparency of the loan market has been shown to affect the portfolio decision of the bank, it also has a impact on economic welfare. In this paper we use an ex ante welfare concept: welfare is defined as the ex ante expected utility of the bank. One might expect that less return uncertainty due to more market transparency would generally be welfare enhancing. However, the literatur shows that this is not necessarily the case (e.g., Hirshleifer, 1971, 1975; Schlee, 2001; Eckwert and Zilcha, 2001, 2003). The reason for this ambiguity is that in economic settings where agents can share risks, more transparency typically affects the risk allocation and, thereby, economic welfare.

In our model the bank's optimal utility level for a given futures rate, $r_F(y)$, conditional on the observed signal, y, is given by $U[\Pi^*(r_F(y))]$. We define the bank's welfare as the ex ante expected utility $\bar{U}^*$, by

$$\bar{U}^* = \int_Y U[\Pi^*(r_F(y))]n(y)\,\mathrm{d}y. \tag{16}$$

With more market transparency, from an ex ante perspective the future rate becomes riskier as it reacts more sensitively to random signal changes. Through this mechanism, higher transparency imposes welfare costs on the risk-averse bank. In the literature this effect has been called the Hirshleifer effect. The (negative) Hirshleifer effect is caused by a deterioration of the risk allocation; and this effect is more important if risk aversion is higher. On the other hand, the greater informational content of the signal permits the bank to better predict the future state of the economy which may result in welfare gains. This is the Blackwell effect. The total impact of higher transparency in the loan market on economic welfare consists of these two opposing effects.

Proposition 3 *More transparency in the loan market raises economic welfare if the bank is either risk-neutral or if absolute risk aversion is uniformly sufficiently small. If the bank's preferences exhibit high absolute risk aversion, economic welfare may decline with higher loan market transparency.*

Proof By Lemma 1, $\bar{U}^*$ increases (decreases) with more market transparency if $U[\Pi^*(r_F))]$ is convex (convave) in the futures rate r_F. Differentiating $U[\Pi^*(r_F)]$ twice with respect to the futures rate yields

$$\frac{\partial^2 U(\Pi^*)}{\partial r_F^2} = U'(\Pi^*)L^{*2}\left[-R^a(\Pi^*) + \frac{L^{*\prime}(r_F)}{L^*}\right], \qquad (17)$$

where $R^a(\Pi^*) := -U''(\Pi^*)/U'(\Pi^*)$ denotes the measure of absolute risk aversion. Since $L^{*\prime}(r_F)$ is positive by Eq. (9), the claim follows from Eq. (16).

While more market transparency reduces the uncertainty at the time the signal can be observed, from an ex ante point of view less risk can be shared through trading on the futures market. Thus, even though the risk allocation is conditionally efficient given the signal realizations, higher transparency makes the risk allocation less efficient from an ex ante perspective. This Hirshleifer effect reduces economic welfare and may dominate the Blackwell effect if the bank is highly risk-averse.

5 Conclusions

In this paper we revisited the decision problem of a bank which acts as financial intermediary between private savers and investors. The bank sells deposits to savers, extends risky loans to investors, and engages in trade on a futures market. The return uncertainty of the bank loans was modelled through an information system which conveys noisy information signals about the unknown loan returns. We have identified higher transparency in the banking sector with a more reliable information system. As such, the degree of transparency determines not only the uncertainty under which the bank chooses its deposit-loan portfolio, but may also affect the terms of trade on a futures market. This information-induced interaction adds a new dimension to the bank's decision problem which makes it different from the standard approach with exogenous uncertainty.

Our analysis has shown that the impact of higher transparency on the behavior of the bank is largely independent of the bank's risk-averse preferences. In particular, more transparency always raises expected profits; and the impact on the expected loan volume can be characterized solely in terms of the curvature of marginal loan management costs. Yet, since the terms of risk sharing are affected by the precision of the signals, the consequences for economic welfare are ambiguous: depending on the bank's attitudes towards risk, economic welfare may increase or decline with higher transparency.

Our findings may have some practical relevance for the regulation of the banking industry. In fact, to the extent that bank accounting information contains forward looking information about loan returns, our model could shed some light on the channels through which stricter regulatory requirements for the disclosure of balance sheet items in the banking sector affect loan volumes, profits, and economic welfare. Due to the model's simplicity, however, these implications should be handled with care. A framework with a richer set of interactions between financial institutions, private investors/savers, and risk sharing arrangements might yield further insights into the role of transparency in the banking sector for the functioning of a market-oriented economy. This is left for future research.

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